Appendix A7

Design Example: Wet Extended Detention Pond

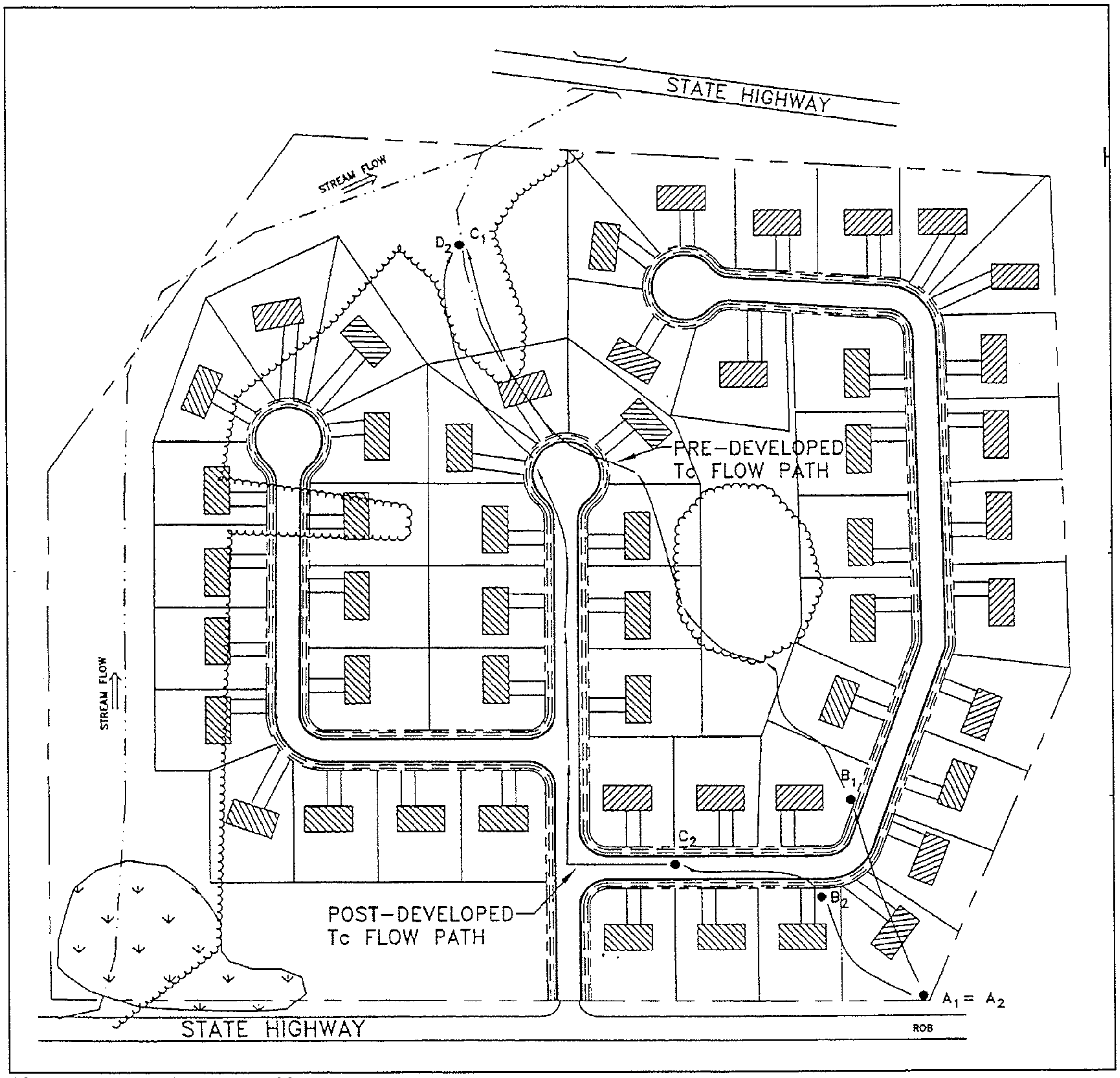


Figure 1. The Meadows Site

Base Data	Hydrologic Data		
Location: Indianapolis, IN		Pre	Post
Site Area = Total Drainage Area (A) = 38.0 ac	CN	65	78
Measured Impervious Area=13.8 ac; or I=13.8/38=36.3%	t_c	.32 hr	.17 hr
Soils Types: 60% "C", 40% "B"			
Zoning: Residential (½ acre lots)			

Compute Stormwater Volumes and Peak Discharges

Step 1: Compute the WQ_v

Runoff coefficient: $R_v = 0.05 + 0.009(I)$

$0.05 + (0.009)(36.3) = 0.38$

$$WQ_v = \frac{(P)(R_v)(A)}{12}$$

$(1)(0.38)(38)/12 = 1.2$ ac-ft

Step 2: Compute Peak Discharges

Detention Requirements:

Q_2 post-development = 50% Q_2 pre-development
Q_{100} post-development = Q_{10} pre-development

Pre-development conditions	Post-development conditions
t_c = 15 mins	t_c = 5 mins
CN = 72	CN = 86
C = 0.25 (0.3 for volume computations)	C = 0.85
Q_2 = 28.22 cfs	Q_2 = 153.43 cfs
Q_{10} = 43.23 cfs	Q_{100} = 312.99 cfs (1.25 x 312.99 cfs = 391.24 cfs for emergency spillway)

Step 3: Determine Feasibility of an Extended Detention Wet Pond.

The total drainage to the pond is 38 acres. Soil borings found that the seasonably high water table is 1 foot below the depth of the pond. The soils are sandy/clay, suitable for an embankment and to support a wet pond without a liner.

Step 4: Determine pretreatment volume for the sediment forebay

Size forebay to contain 0.1 inches of runoff per impervious acre. Forebay volume will be included in WQ_v as part of the permanent pool volume.

(13.8 ac)(0.1 inch)(1' / 12 inches) = 0.12 ac-ft

Step 5: Determine permanent pool volume and water quality extended detention volume (ED).

Size permanent pool volume to contain 50% of WQ_v.

(0.5)(1.2 ac-ft) = 0.6 ac-ft (includes 0.12 ac-ft of storage in forebay)

Design ED volume to contain 50% of the WQ_v = 0.6 ac-ft

Step 6: Determine pond location and preliminary geometry.

This step involves establishing contours and determining the stage-storage relationship for the pond. Storage must be provided for the permanent pool and to meet the detention requirements.

Elevation	Average Area, ft^2	Depth, ft	Volume, ft^3	Cumulative Volume, ft^3	Cumulative Volume, ac-ft	Volume Above Permanent Pool, ac-ft
920.0						
921.0	7838	1	7838	7838	0.18	
923.0	11450	2	22900	30738	0.71	
924.0	14538	1	14538	45275	1.04	0
925.0	15075	1	15075	60350	1.39	.035
925.5	16655	0.5	8328	68678	1.58	0.54
926.0	17118	0.5	8559	77236	1.77	0.73
926.5	21000	0.5	10500	87736	2.01	0.97
927.0	25000	0.5	12500	100236	2.30	1.26
927.5	30000	0.5	15000	115236	2.65	1.61
928.0	36000	0.5	18000	133236	30.6	2.02
928.5	38000	0.5	19000	152236	3.49	2.46
929.0	41000	0.5	20500	172736	3.97	2.93
929.5	43000	0.5	21500	194236	4.46	3.42
930.0	45000	0.5	22500	216736	4.98	3.94
930.5	47000	0.5	26500	240236	5.52	4.48
931.0	49000	0.5	24500	264736	6.08	5.04
931.5	52000	0.5	26000	290736	6.67	5.64
932.0	55000	0.5	27500	318236	7.31	6.27
932.5	58000	0.5	29000	347236	7.97	6.93
933.0	61000	0.5	30500	377736	8.67	7.63
933.5	65000	0.5	32500	410236	9.42	8.38
934.0	69000	0.5	34500	444736	10.21	9.17

Set pond basics.

- Pond bottom elevation = 920
- Set barrel outlet at 919

Set water surface and other elevations.

- Required permanent pool volume 50% WQ_v = 0.6 ac-ft. At elevation 924, the storage provided is 1.04 ac-ft, which is adequate for the WQ_v and for a factor of safety.
- Forebay volume in 2 pools with average volume = 0.08 ac-ft, exceeding the required 0.12 ac-ft
- Required extended detention volume (WQ_v-ED) = 0.6 ac-ft. Elevation 926 provides 0.73 ac-ft of storage, exceeding the required storage. Set ED water surface elevation = 926. Note that the total storage provided at elevation 926 = 1.77 ac-ft, exceeding the required WQ_v of 1.2 ac-ft.

Calculate the required WQ_v-ED orifice diameter to release 0.6 ac-ft over 24 hours.

- Avg. release rate = (0.6 ac-ft)(43,560 ft2/ac) / (24 hrs)(3600 secs/hr) = 0.30 cfs
- Avg. head = (926 – 924) / 2 = 1'
- Use orifice equation to compute cross sectional area and diameter
  - $Q = CA2(gh)^{0.5}$ for Q = 0.30 cfs, h=1.0 ft., C = 0.6 = discharge coefficient
  - A = 0.06 ft^2; $A = \pi d^2 / 4$; diameter = 0.27 ft or 3.3"
  - Use 4" pipe with a 4" gate valve to achieve an equivalent diameter

Determine the stage-discharge for the 3.7" WQv orifice

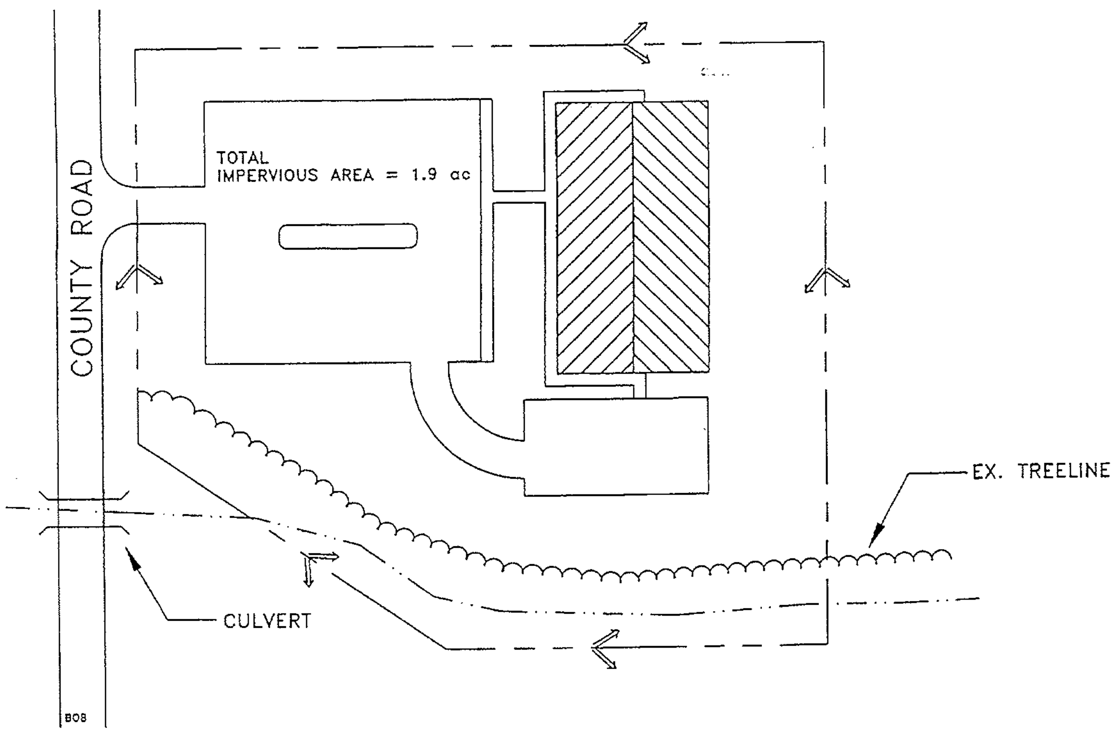
- $Q_{WQvED} = CA2(gh)^{0.5} = (0.6)(0.075)(2)[(32.2\ ft/sec^2)^{0.5}(h)^{0.5}]$
- $Q_{WQvED} = (0.36)h^{0.5}$ where h = wsel – 924

Set spillway system for detention requirements:

- Use 3'x 3' box riser with invert elevation of 931.5 with 36" RCP barrel and a 12" orifice set at elevation 926
- Using a computer program to route the 2yr storm through the spillway system gives a Q_{out} = 5.09 which is less than Q_2 pre-development
- Using a computer program to route the 100yr storm through the spillway system, gives a Q_{out}= 50.68cfs

Design Example: STORMWATER SWALE

Figure 2 Marion County Recreation Center Site Plan



Base Data	Hydrologic Data		
Location: Indianapolis, Indiana		**Pre**	**Post**
Site Area = Total Drainage Area (A) = 3.0 ac	CN	70	88
Impervious Area = 1.9 ac; or I =1.9/3.0 = 63.3%	t_c	.39	.20
R_v = 0.05 + (63.3) (0.009) = 0.62			
Soils Type "C"			

This example focuses on the design of a dry swale to meet the water quality treatment requirements of the site. Channel protection and overbank flood control is not addressed in this example other than quantification of preliminary storage volume and peak discharge requirements. It is assumed that the designer can refer to the previous pond example in order to extrapolate the necessary information to determine and design the required storage and outlet structures to meet these criteria. In general, the primary function of dry swales is to provide water quality treatment and groundwater recharge and not large storm attenuation. As such, flows in excess of the water quality volume are typically routed to bypass the facility. Where quantity control is required, the bypassed flows can be routed to conventional detention basins (or some other facility such as underground storage vaults).

Computation of Preliminary Stormwater Storage Volumes and Peak Discharges

The layout of the Haubner Recreation Center is shown in Figure 1.

Step 1. Compute Water Quality Volume WQ_v

$$WQ_v = (1") (R_v) (A) / 12$$
$$= (1") (0.62) (3.0ac) (43{,}560ft^2/ac) (1ft/12in)$$
$$= 6751.8 \text{ ft}^3$$

Step 2. Compute Q25:

NRCS TR-55 methodology was used to calculate the peak discharges for the 25 year storm. The peak flow will later be routed through the channel to ensure channel capacity.

Per TR-55

Condition	**CN**	**$Q_{25\text{-year}}$**
		cfs
Pre-developed	70	5
Post-Developed	88	10

Step 3. Analyze for Safe Passage of the 25:

At final design, prove that discharge conveyance channel is adequate to convey the 25- year event and discharge to receiving waters.

Table 1 Summary of General Design Information for Haubner Recreation Center

Step No.	Category	Volume Required (cubic feet)	Notes
1	Water Quality (WQ_v)	6,752	
2	25-year storm event	NA	provide safe passage for the 25-year event in final design

Site Specific Data:

Existing ground elevation at BMP location is 922.0 feet. Soil boring observations reveal that the seasonally high water table is at 913.0 feet and underlying soils are silt loams (ML). Adjacent creek invert is at 912.0 feet.

Step 3 Compute Pretreatment:

Size two shallow forebays at the head of the swales equal to 0.05" per impervious acre of drainage (each) (Note, total recommended pretreatment requirement is 0.1"/imp acre). (1.9 ac) (0.05") (1ft/12") (43,560 sq ft/ac) = 344.9 ft^3

Use a 2' deep pea gravel drain at the head of the swale to provide erosion protection and to assist in the distribution of the inflow.

Step 4. Identify swale dimensions:

Required: bottom width, depth, length, and slope necessary to store WQ_v with less than 18" of ponding (see Figure 6 for representative site plan).

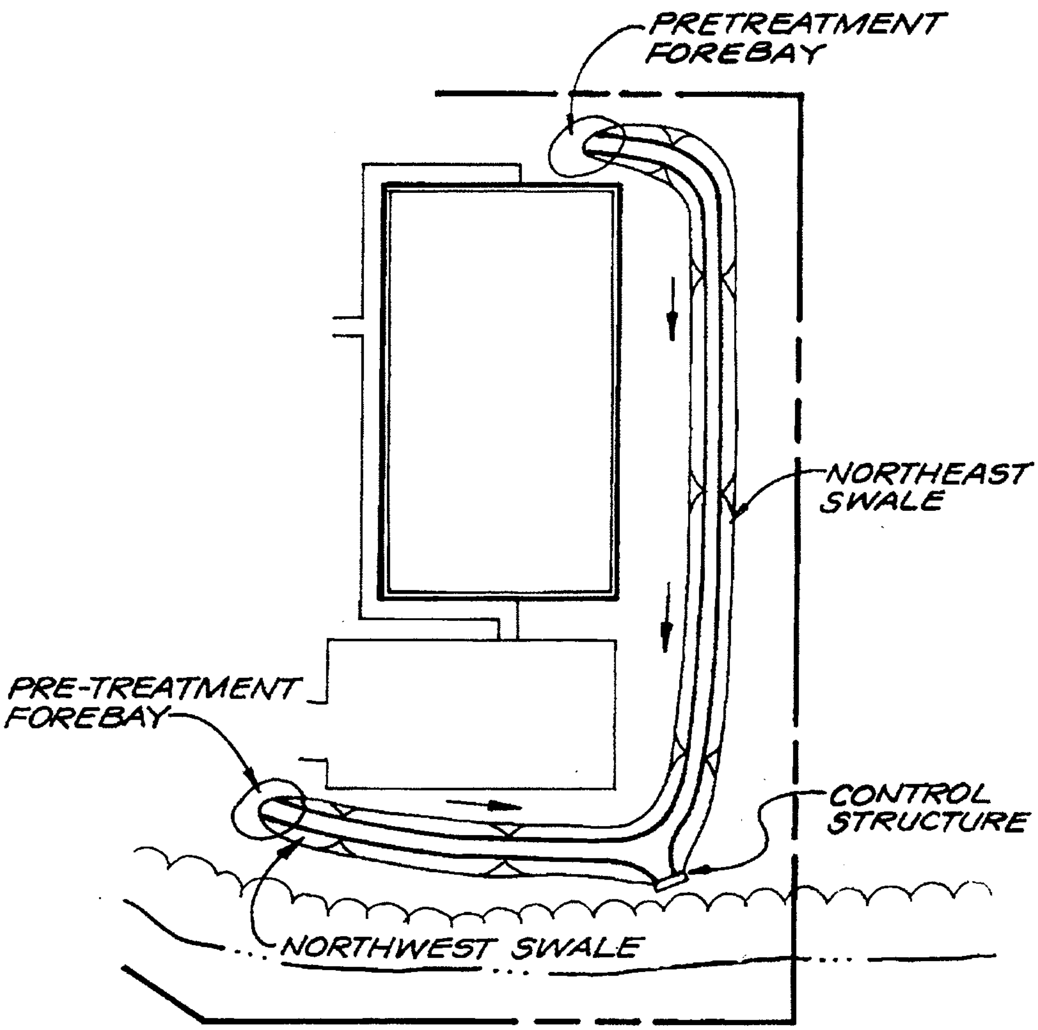


Figure 3 Dry Swale Site Plan

Assume a trapezoidal channel with a maximum WQ_v depth of 18". Control for this swale will be a shallow concrete wall with a low flow orifice, trash rack located per Figures 4 and 5. Per the site plan, we have about 1,100' of swale available, if the swale is put in with two tails. The outlet control will be set at the existing invert minus three feet (922.0 - 3.0 = 919.0). The existing uphill invert for the northwest fork is 924.0 (length of 500'), the invert for the northeast fork is 928.0 (at a length of 600').

Slope of northwest fork is (924 - 919)/500' = 0.01 or 1.0%
Slope of northeast fork is (928 - 919)/600' = 0.01 or 1.0%

minimum slope is 1.0 % [okay]

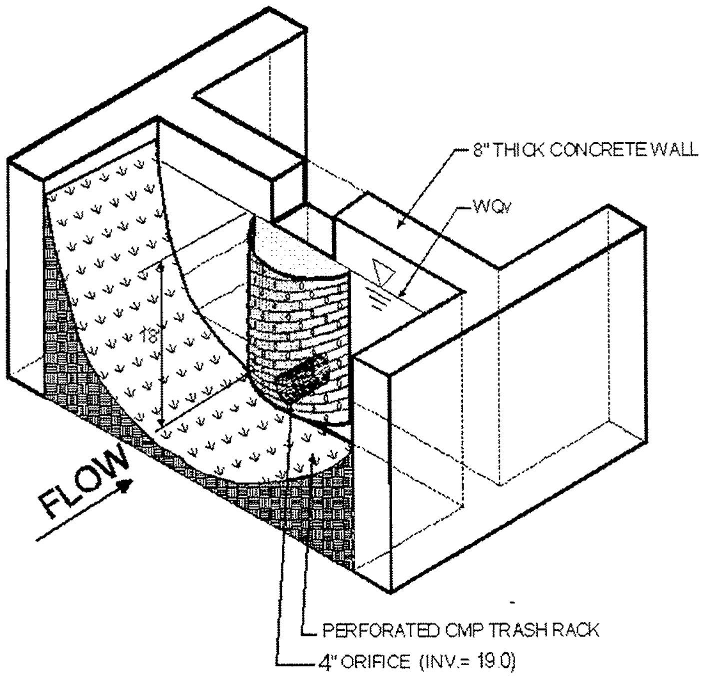


Figure 4 Control Structure at End of Swale

For a trapezoidal section with a bottom width of 6', a WQ_v average depth of 9", 3:1 side slopes, compute a cross sectional area of (6') (0.75') + (0.75') (2.25') = 6.2 ft^2 (see Figure 3).

(6.2 sq ft) (1,100 ft) = 6820 cubic feet [> WQ_v of 6752 ft^3; OK]

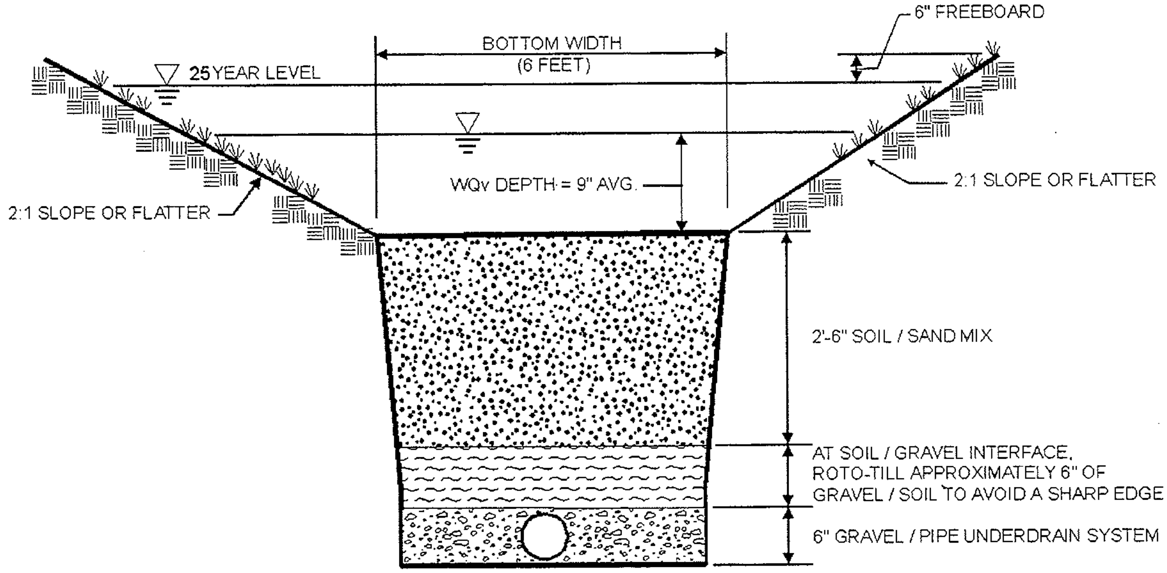


Figure 5 Trapezoidal Dry Swale Section

Step 5. Compute number of check dams (or similar structure) required to detain WQ_v (see Figure 6)

For the northwest fork, 500 ft @ 1.0% slope, and maximum depth at 18", place checkdams at: 1.5'/0.01 = 150' place at 150', 4 required

For the northeast fork, 600 ft @ 1.0% slope, and maximum 18" depth, place checkdams at 1.5'/0.01 = 150' place at 150', 4 required

Step 6. Calculate draw-down time

In order to ensure that the swale will draw down within 24 hours, the planting soil will need to pass a maximum rate of 1.5' in 24 hours (k = 1.5' per day). Provide 6" perforated underdrain pipe and gravel system below soil bed (see Figure 6)

Step 7. Check 25-year velocity erosion potential and freeboard:

From TR-55 information, the 25-year flow is 10 cfs, assume that 30% goes through northwestern swale (3 cfs) and 70% goes through the northeastern swale (7 cfs). Design for the larger amount (7 cfs). From separate computer analysis, with a slope of 1.0%, the 25-year velocity will be 2.3 feet-per-second at a depth of 0.4 feet.

Find 25-year overflow weir length required: (weir eq. $Q = CLH^{3/2}$), where C = 3.1, Q_{25} = 10 cfs, H =1.2

Rearranging the equation yields:

$L = 10 \text{ cfs} / (3.1 * 1.2^{1.5}) = 2.5'$ Use 3 ft

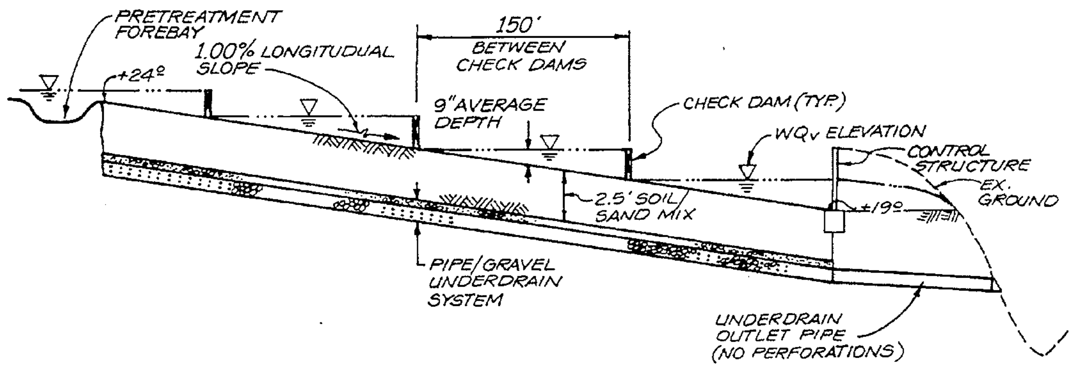


Figure 6 Profile of Northwest Fork Dry Swale

Step 8. Specify vegetation:

Use tall fescue grass or other appropriate vegetation

Step 9. Design low flow orifice at headwall (See Figure 4):

Design orifice to pass 6,752 cubic feet in 6 hours.

6,752 cubic feet/ [(6 hours) (3600 sec/hour)] = 0.3 cfs

use Orifice equation: $Q = CA(2gh)^{1/2}$

assume h = 1.5'

$A = (0.3 \text{ cfs}) / [(0.6)\ ((2)\ (32.2 \text{ ft/s}^2)\ (1.5'))^{1/2}]$

A = 0.05 sq ft, dia = 0.01 feet or >0.5" use 0.5" orifice

provide 3" v-notch slot in each check dam to prevent erosion at structure's abutment.

Water Quality Swale Design Summary Worksheet

Step 1. Identify site specific information	Site acreage:	Acres
	Total percent impervious area (I):	%
	Total DA to BMP (A):	Acres
Step 2. Confirm design criteria	Design for WQ_V?	Y N
	Design for quantity control?	Y N
	Water quality can provide a limited amount of water quantity control.	
Step 3. WQ_V design $WQ_V = \frac{(P)(R_V)(A)}{12}$ $R_V = 0.05 + (0.009)(I)$		
	R_V:	______
	WQ_V:	______ ac-ft

b

Step 4. Complete downstream analysis. Attach calculations to verify analysis, methods used, and conclusions. Include maps to indicate the point of analysis. If more than 2 sub-basins are within the project, include additional summary sheets.

The downstream analysis should extend to the point where 10% or less of the total watershed area contributing flow to the downstream point originates from the larger of the total site area or the subject BMP watershed area to that outlet point from the site.

Q = peak discharge
Vr = runoff volume
fw = flow width
v = velocity

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs
Vr2	ac-ft	Vr2	ac-ft
Vr10	ac-ft	Vr10	ac-ft
Vr100	ac-ft	Vr100	ac-ft
fw	ft	fw	Ft
v	fps	v	Fps

Sub-basin 2

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs
Vr2	Ac-ft	Vr2	Ac-ft
Vr10	Ac-ft	Vr10	Ac-ft
Vr100	Ac-ft	Vr100	Ac-ft
fw	ft	fw	Ft
v	fps	v	Fps

Step 5. Determine detention requirements, if needed.

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs

Step 6. If detention is required, what type of BMP will be installed? Provide the design summary sheet for the detention BMP. If the water quality swale is to be used in a treatment train to control water quantity, route the 2-year and 100-year storms through the facilities to show peak reductions as required in Chapter 300.	Wet pond Wetland Underground Mixed (Circle one) *Provide the design summary sheet for the detention BMP(s) and routing (if appropriate).*	
Step 7. Determine pretreatment volume. The treatment volume can be subtracted from the overall WQv. $Vt = 0.1 \text{inches} \times \frac{1 ft}{12 in} \times DA_{imp}$ where: DA_{imp} = impervious acreage of contributing drainage area, ac Vt = treatment volume, ac-ft	Vt	_____________ac-ft
Step 8. Determine swale dimensions necessary to store the WQv (less the Vt if appropriate). Ponding depth should be no more than 18 inches.	Bottom width	____________ft (2-8 ft)
	Depth	____________ft
	Length	____________ft
	Side slopes	____________ (3:1 or flatter)
	Area	_________ft2
	Slope	__________ ft/ft
Step 9. Compute number of check dams required to store the WQv. $\text{Number} = \frac{\text{Depth, ft} \times \text{slope, ft/ft}}{\text{length}}$	Number	_____________
Step 10. Set design elevations and dimensions of facility.	*Provide cross-sectional view through facility showing elevations and dimensions.*	
Step 11. Design the underdrain system.	*See Section 702.03.*	
Step 12. Design conveyances to facility.	*See Section 303.01 for more details* • Establish the area inundated in the 25-year storm event and set the area as a dedicated easement • Delineate the 100-year flood line • Design channel lining for the 10-year storm event	
Step 13. Design emergency spillway to bypass or convey larger flows to the downstream drainage system. Design for non-erosive velocities at the discharge point.		

Step 14. Attach landscape plan	*See Section 702.02*
Notes:	

Stormwater Pond Design Summary Worksheet

Step 1. Identify site specific information	Site acreage:	Acres
	Total percent impervious area (I):	%
	Total DA to BMP (A):	Acres
Step 2. Confirm design criteria	Design for WQ_V?	Y N
	Design for detention?	Y N
Step 3. WQ_V design $WQ_V = \frac{(P)(R_V)(A)}{12}$ $R_V = 0.05 + (0.009)(I)$		
	R_V:	
	WQ_V:	ac-ft

Step 4. Complete downstream analysis. Attach calculations to verify analysis, methods used, and conclusions. Include maps to indicate the point of analysis. If more than 2 sub-basins are within the project, include additional summary sheets.

The downstream analysis should extend to the point where 10% or less of the total watershed area contributing flow to the downstream point originates from the larger of the total site area or the subject detention/retention basin watershed area to that outlet point from the site.

Q = peak discharge
Vr = runoff volume
fw = flow width
v = velocity

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs
Vr2	ac-ft	Vr2	ac-ft
Vr10	ac-ft	Vr10	ac-ft
Vr100	ac-ft	Vr100	ac-ft
fw	ft	fw	ft
v	fps	v	fps

Sub-basin 2

Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs
Vr2	Ac-ft	Vr2	Ac-ft
Vr10	Ac-ft	Vr10	Ac-ft
Vr100	Ac-ft	Vr100	Ac-ft
fw	ft	fw	ft
v	fps	v	fps

Step 5. Calculate detention requirements.

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs

Step 6. Determine storage available for permanent pool.	*Prepare an elevation-storage table and curve using the average area method for computing volumes.*

Elevation msl	Area ft3	Average area ft2	Depth ft	Volume ft3	Cumulative volume ft3	Cumulative volume ft3	Volume above permanent pool ac-ft

Step 7. Set outlet sizes, heights and WSEL.	Permanent pool	h =	ft
	Area of orifice from orifice equation $Q = CA(2gh)^{0.5}$	A=	ft^2
		Diameter =	in
	Discharge equation Q = (h)^0.5	Factor =	______(h)^0.5

Step 8. Calculate Q2, Q10 and Q100 release rates and WSEL	*Set up stage-storage-discharge relationships*

Q2

Elevation	Storage	Low flow WQv	Riser				Barrel				Emergency spillway		Total storage
			Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft) Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q(cfs)

Q10

Elevation	Storage	Low flow WQv	Riser				Barrel				Emergency spillway		Total storage
			Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft) Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q(cfs)

Q100

Elevation	Storage	Low flow WQv	Riser				Barrel				Emergency spillway		Total storage
			Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft) Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q (csf)

	Check inlet condition Check outlet condition	*Use pipe charts*
Step 8. Size emergency spillway, calculate 100 year WSEL and set top of embankment elevation.	WSEL100 Q100	__________ ft __________ cfs
Step 9. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.	*See Chapter 700.*	
Step 10. Attach cross-sectional view through embankment and spillways.		
Step 11. Attach landscape plan		

Notes:

Stormwater Wetland Design Summary Worksheet

Step 1. Identify site specific information	Site acreage:	Acres
	Total percent impervious area (I):	%
	Total DA to BMP (A):	Acres
Step 2. Confirm design criteria	Design for WQ_V?	Y N
	Design for detention?	Y N
Step 3. WQ_V design $WQ_V = \frac{(P)(R_V)(A)}{12}$ $R_V = 0.05 + (0.009)(I)$	R_V:	
	WQ_V:	ac-ft
Step 4. Set total surface area. SA = DA x 1% SA = DA x 1.5% (shallow wetland)	SA =	__________ft2
Step 5. Set the length to width ratio, allocate the WQv among marsh and micropool, and allocate surface area.	See Table 702.02-01 Recommended Design Criteria for Stormwater Wetlands	
Step 6. Compute monthly water balance, showing the wetland can withstand a 30-day drought at summer ET rates without completely drawing down. S = Qi + R + Inf - Qo – ET Where: S = net change in storage Qi = stormwater runoff inflow R = contribution from rainfall Inf = net infiltration (infiltration – exfiltration) Qo = surface outflow ET = evapotranspiration	ET = (summer rate with 30day drought)	__________
	Qo =	__________
	Inf =	__________
	R =	__________
	Qi =	__________
	S =	__________

Step 7. Complete downstream analysis. Attach calculations to verify analysis, methods used, and conclusions. Include maps to indicate the point of analysis. If more than 2 sub-basins are within the project, include additional summary sheets.

See Section 201 for more information on downstream analysis.

Q = peak discharge
Vr = runoff volume
fw = flow width
v = velocity

Sub-basin 1			
Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs
Vr2	ac-ft	Vr2	ac-ft
Vr10	ac-ft	Vr10	ac-ft
Vr100	ac-ft	Vr100	ac-ft
fw	ft	fw	ft
v	fps	v	fps

	Sub-basin 2			
	Predevelopment		Post development	
	Q2	cfs	Q2	cfs
	Q10	cfs	Q10	cfs
	Q100	cfs	Q100	cfs
	Vr2	Ac-ft	Vr2	Ac-ft
	Vr10	Ac-ft	Vr10	Ac-ft
	Vr100	Ac-ft	Vr100	Ac-ft
	fw	ft	fw	ft
	v	fps	v	fps

Step 8. Calculate detention requirements.

Sub-basin 1			
Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs

Sub-basin 2			
Predevelopment		Post development	
Q2	cfs	Q2	cfs
Q10	cfs	Q10	cfs
Q100	cfs	Q100	cfs

Step 9. Determine storage available for permanent pool.

Prepare an elevation-storage table and curve using the average area method for computing volumes.

Elevation msl	Area ft3	Average area ft2	Depth ft	Volume ft3	Cumulative volume ft3	Cumulative volume ft3	Volume above permanent pool ac-ft

Step 10. Set outlet sizes, heights and WSEL.

Permanent pool	h =	ft
Area of orifice from orifice equation $Q = CA(2gh)^{0.5}$	A=	ft^2
	Diameter =	in
Discharge equation Q = (h)^0.5	Factor =	____(h)^0.5

Step 11. Calculate Q2, Q10 and Q100 release rates and WSEL	*Set up stage-storage-discharge relationships*

Q2

Elevation	Storage	Low flow WQv		Riser				Barrel				Emergency spillway		Total storage
				Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft)	Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q(cfs)

Q10

Elevation	Storage	Low flow WQv		Riser				Barrel				Emergency spillway		Total storage
				Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft)	Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q(cfs)

Q100

Elevation	Storage	Low flow WQv		Riser				Barrel				Emergency spillway		Total storage
				Orif.		Weir		Inlet		Pipe				
MSL	ac-ft	H(ft)	Q(cfs)	H	Q	H	Q	H	Q	H	Q	H	Q	Q (csf)

	Check inlet condition Check outlet condition	*Use pipe charts*
Step 13. Set WQv WSEL	WSEL WQv	___________ft
Step 14. Size emergency spillway, calculate 100 year WSEL and set top of embankment elevation.	WSEL100 Q100	___________ ft ___________ cfs

Step 15. Design inlets, sediment forebays, outlet structures, maintenance access and safety features.	*See Chapter 700.*
Step 16. Attach cross-sectional view through embankment and outlet structures.	
Step 17. Attach landscape plan	
Notes:	

Bioretention Design Summary Worksheet

Step 1. Identify site specific information	Site acreage:	Acres
	Total percent impervious area (I):	%
	Total DA to BMP (A):	Acres
Step 2. Confirm design criteria	Design for WQ_V?	Y N
	Bioretention cannot be designed as a water quantity BMP	
Step 3. WQ_V design $WQ_V = \frac{(P)(R_V)(A)}{12}$ $R_V = 0.05 + (0.009)(I)$		
	R_V:	________
	WQ_V:	________ ac-ft

Step 4. Complete downstream analysis. Attach calculations to verify analysis, methods used, and conclusions. Include maps to indicate the point of analysis. If more than 2 sub-basins are within the project, include additional summary sheets.

The downstream analysis should extend to the point where 10% or less of the total watershed area contributing flow to the downstream point originates from the larger of the total site area or the subject detention/retention basin watershed area to that outlet point from the site.

Q = peak discharge
Vr = runoff volume
fw = flow width
v = velocity

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs
Vr2	ac-ft	Vr2	ac-ft
Vr10	ac-ft	Vr10	ac-ft
Vr100	ac-ft	Vr100	ac-ft
fw	ft	fw	Ft
v	fps	v	Fps

Sub-basin 2

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs
Vr2	Ac-ft	Vr2	Ac-ft
Vr10	Ac-ft	Vr10	Ac-ft
Vr100	Ac-ft	Vr100	Ac-ft
fw	ft	fw	Ft
v	fps	v	Fps

Step 5. Determine detention requirements, if needed.

Sub-basin 1

Predevelopment		Post development	
Q2	cfs	Q2	Cfs
Q10	cfs	Q10	Cfs
Q100	cfs	Q100	Cfs

Step 6. If detention is required, what type of BMP will be installed? Provide the design summary sheet for the detention BMP.	Wet pond Wetland Underground (Circle one) *Provide the design summary sheet for the detention BMP.*
Step 7. Design the pretreament filter strip.	*Provide the design summary sheet for the filter strip.*
Step 8. Size flow diversion structure, if needed, to divert the WQv to the bioretention area.	
Step 9. Determine the size of bioretention ponding/filter area. Darcy's Law: Af = (WQv)(df) / [(k)(hf + df)(tf)] Where Af = surface area of ponding area (ft2) WQv = water quality volume df = filter bed depth (4' minimum) k = coefficient of permeability of filter media (ft/day) (use 0.5 ft/day for silt-loam) hf = average height of water above filter bed (ft) (typically 3 inches, which is half of the 6 inch ponding depth) tf = design filter bed drain time (days) (2.0 days or 48 hours is recommended maximum)	Af ____________ ft2 Df ____________ft k ____________ft/day Hf ____________ft tf ____________day(s)
Step 10. Set design elevations and dimensions of facility.	*Provide cross-sectional view through facility showing elevations and dimensions.*
Step 11. Design the underdrain system.	*See Section 702.03.*
Step 12. Design conveyances to facility.	*See Section 303.01 for more details* • Establish the area inundated in the 25-year storm event and set the area as a dedicated easement • Delineate the 100-year flood line • Design channel lining for the 10-year storm event
Step 13. Design emergency spillway to bypass or convey larger flows to the downstream drainage system. Design for non-erosive velocities at the discharge point.	
Step 14. Attach landscape plan	*See Section 702.02*
Notes:	

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Appendix B7 Hydric Soils List

The following list of hydric soil symbols refers to symbols on the USDA NRCS Soil Survey Of Marion County, Indiana soils maps. For a copy of the map, contact:

Indiana State USDA NRCS Office
6013 Lakeside Boulevard
Indianapolis, Indiana 46278-2933
Phone: (317) 290-3200

Symbol	Name	Hydric Soil Component Name	Local of Hydric Soil Component
Br	Brookston Silty Clay Loam	Brookston	Depressions, potholes and drainageways
Re	Rensselaer Clay Loam	Rensselaer	Depressions and Drainageways
Sn	Sloan Silt Loam	Sloan	Oxbows and depressions
Ub	Urban land – Brookston Complex	Brookston	Depressions, potholes and drainageways
Uw	Urban land – Westland Complex	Westland	Drainageways
We	Westland Clay Loam	Westland	Drainageways
CrA	Crosby Silt Loam, 0 to 2 percent slopes	Brookston	Depressions and potholes
CsB2	Crosby-Miami Silt Loams, 2 to 4 percent slopes	Brookston	Depressions
FoA	Fox Loam, 0 to 2 percent slopes	Westland	Depressions
MmB2	Miami Silt Loam, 2 to 6 percent slopes, eroded	Brookston	Depressions
MmC2	Miami Silt Loam, 6 to 12 percent slopes, eroded	Brookston	Depressions
Sh	Shoals Silt Loam	Sloan	Depressions
Sk	Sleeth Loam	Westland	Depressions
Uc	Urban land – Crosby	Brookston	Depressions

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Appendix C7 Wetland Plant Listing for Indiana

Plants found in this list are suitable for Indiana and can be found in local specialty nurseries. For more information on plating times and seeding rates (if applicable), contact the local USDA NRCS office at

Indiana State USDA NRCS Office
6013 Lakeside Boulevard
Indianapolis, Indiana 46278-2933
Phone: (317) 290-3200

The wetland communities noted in the table below are generally described by the following:

Shallow Water Emergent: Wetland areas where the water depth ranges from 0 to 1 foot.
Sedge Meadow: Saturated soils typically near the normal or high water level

Scientific Nabbme	Common Name	Community	Exposure	Notes
Acorus calamus	Sweet Flag	Shallow water emergent	Full sun to part shade	1-3 feet tall
Asclepias incarnata	Marsh Milkweed	Sedge Meadow	Full sun	3-4 feet tall
Aster firmus	Shining Aster	Sedge Meadow	Full sun	3-4 feet tall
Aster novae-angliae	New England Aster	Sedge Meadow	Full sun	
Aster puniceus	Swamp Aster	Sedge Meadow	Full sun	4-6 feet tall
Aster umbellatus	Flat Top Aster	Sedge Meadow	Full sun	3-6 feet tall
Caltha palustris	Marsh Marigold	Shallow water emergent	Full sun	1-2 feet tall
Cephalanthus occidentalis	Buttonbush	Shallow water emergent	Full sun to part shade	8-12 feet tall
Chelone glabra	White Turtlehead	Shallow water emergent	Part shade	3-4 feet tall
Chelone obliqua	Pink Turtlehead	Shallow water emergent	Part shade	2-4 feet tall
Eupatorium fistulosum	Hollow Joe-Pye Weed	Sedge Meadow	Full sun	6-10 feet tall
Eupatorium maculatum	Spotted Joe-Pye Weed	Sedge Meadow	Full sun	4-6 feet tall
Eupatorium perfoliatum	Boneset	Sedge Meadow	Full sun	4-6 feet tall
Eupatorium rugosum	White Snakeroot	Sedge Meadow	Shade	2-3 feet tall
Filipendula rubra	Queen of the Prairie	Shallow water emergent	Full sun	4-6 feet tall
Gentiana andrewsii	Bottle Gentian	Sedge Meadow	Full sun or part shade	12-18 inches tall
Helenium autumnale	Autumn Sneezeweed	Sedge Meadow	Full sun	3-5 feet tall
Hibiscus palustris	Swamp Rose Mallow	Shallow water emergent	Full sun	4-6 feet tall
Hypericum pyramidatum	Great St. Johnswort	Sedge Meadow	Full sun	6 feet tall

Scientific Nabbme	Common Name	Community	Exposure	Notes
Iris versicolor	Wild Iris	Shallow water emergent	Full sun	
Iris virginica shrevei	Blue Flag	Shallow water emergent	Full sun	
Lobelia cardinalis	Cardinal Flower	Sedge Meadow	Full sun or part shade	2-5 feet tall
Lobelia siphilitica	Great Blue Lobelia	Sedge Meadow	Full sun or part shade	2-3 feet tall
Mentha arvensis	Common Mint	Sedge Meadow	Full sun	
Mimulus ringens	Monkeyflower	Sedge Meadow	Full sun	2-4 feet tall
Physocarpus opulifolius	Ninebark	Sedge Meadow	Full sun or part shade	4-7 feet tall
Physostegia virginiana	Obedient Plant	Sedge Meadow	Full sun	2-4 feet tall
Pontederia cordata	Pickerel Weed	Shallow water emergent	Full sun or part shade	
Sagittaria latifolia	Common arrowhead	Shallow water emergent	Full sun or part shade	Vigorous spreader; tolerates fluctuating water levels
Saururus cernuus	Lizard's Tail	Shallow water emergent	Full sun or shade	
Senecio aureus	Golden Ragwort	Sedge Meadow	Part shade	12 inches tall
Solidago ohioensis	Ohio Goldenrod	Sedge Meadow	Full sun	2-3 feet tall
Solidago patula	Swamp Goldenrod	Sedge Meadow	Full sun to part shade	4-6 feet tall; spreads by rhizomes
Solidago riddellii	Riddell's Goldenrod	Sedge Meadow	Full sun	2-4 feet tall; spreads by rhizomes
Sparganium eurycarpum	Giant Burreed	Shallow water emergent	Full sun	3-5 feet tall; spreads slowly by rhizomes
Veronica fasciculata	Smooth Ironweed	Sedge Meadow	Full sun	3-6 feet tall
Bromus latiglumis	Tall Brome	Sedge Meadow	Shade	3-5 feet tall
Carex bromoides	Brome Hummock Sedge	Sedge Meadow	Part shade	
Carex crinita	Fringed Sedge	Sedge Meadow	Full sun or part shade	2-4 feet tall
Carex cristatella	Crested Sedge	Sedge Meadow	Full sun or part shade	2-3 feet tall
Carex emoryi	Riverbank Tussock Sedge	Sedge Meadow	Full sun to part shade	Vigorous grower
Carex frankii	Frank's Sedge	Sedge Meadow	Sun or shade	1-2 feet tall; tolerated drying
Carex granularis	Meadow Sedge	Sedge Meadow	Sun or shade	1 foot tall
Carex grayi	Burr Sedge	Sedge Meadow	Sun or shade	2 feet tall
Carex lacustris	Lake Sedge	Sedge Meadow	Sun or shade	Vigorous grower; spreads by rhizomes
Carex lurida	Bottlebrush sedge	Sedge Meadow	Full sun to part shade	1-3 feet tall

Scientific Nabbme	Common Name	Community	Exposure	Notes
Carex muskingumensis	Palm Sedge	Sedge Meadow	Shade	
Carex radiata	Straight-Styled Wood Sedge	Sedge Meadow	Shade	8-12 inches tall
Carex shortiana	Short's Sedge	Sedge Meadow	Sun or shade	2-3 feet tall; vigorous grower
Carex stipata	Awl-Fruited Sedge	Sedge Meadow	Sun or shade	1-3 feet tall
Carex stricta	Tussock Sedge	Sedge Meadow	Full sun to part shade	2-3 feet tall
Carex trichocarpa	Hairy-Fruited Lake Sedge	Sedge Meadow	Full sun to part shade	Vigorous grower; spreads by rhizomes
Carex vulpinoidea	Fox Sedge	Sedge Meadow	Full sun or part shade	2-3 feet tall; tolerates drying
Chasmanthium latifolium	Northern Sea Oats	Sedge Meadow	Partial or full shade	2-3 feet tall
Eleocharis erythropoda	Creeping Spike Rush	Shallow water emergent	Full sun	15 inches tall; vigorous grower; spreads by rhizomes
Glyceria striata	Fowl Manna Grass	Sedge Meadow	Sun or shade	2-3 feet tall; tolerates drying
Juncus effusus	Soft Rush	Shallow water emergent	Full sun	1-2 feet tall
Juncus torreyi	Torrey's Rush	Shallow water emergent	Full sun	1-2 feet tall; tolerates drying
Leersia oryzoides	Rice Cut Grass	Shallow water emergent	Full sun	2-3 feet tall; tolerates fluctuating water levels
Scirpus acutus	Hard-Stemmed Bulrush	Sedge Meadow	Full sun	5-7 feet tall; tolerates fluctuating water levels
Scirpus atrovirens	Dark Green Bulrush	Sedge Meadow	Full sun	3-5 feet tall
Scirpus cyperinus	Woolgrass	Sedge Meadow	Full sun	4-6 feet tall
Scirpus fluviatilis	River Bulrush	Sedge Meadow	Full sun	4-7 feet tall; spreads rapidly by rhizomes; tolerates fluctuating water levels
Scirpus pungens	Three-Square Bulrush	Sedge Meadow	Full sun	2-4 feet tall; spreads slowly by rhizomes
Scirpus validus	Softstem Bulrush	Sedge Meadow	Full sun	4-7 feet tall
Spartina pectinata	Prairie Cordgrass	Sedge Meadow	Full sun	

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